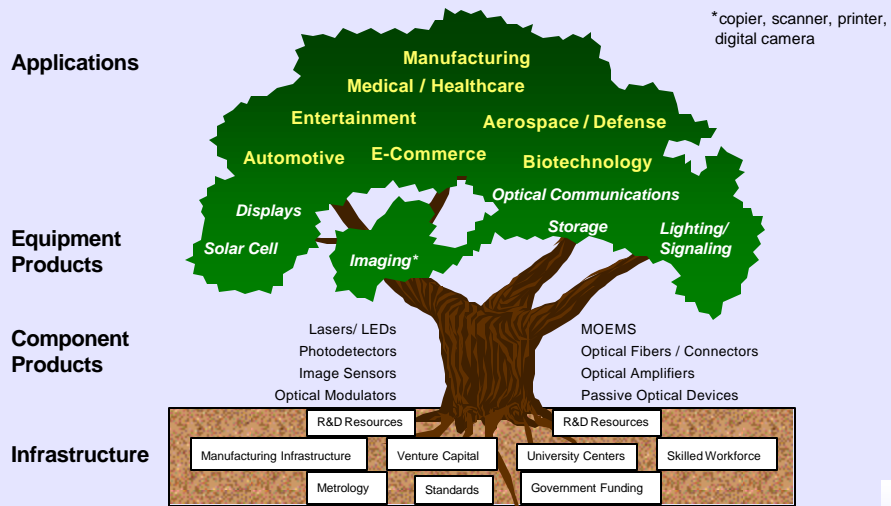

Opportunities in Optoelectronics

Fred Welsh
NIST/ATP National Meeting
November 16, 1999

Outline

- The Optoelectronics Industry
 - Products and Applications
 - Markets Review
 - Future Opportunities
- Competitiveness Issues
 - Manufacturing
 - Cooperation and Competition

The Optoelectronics Industry

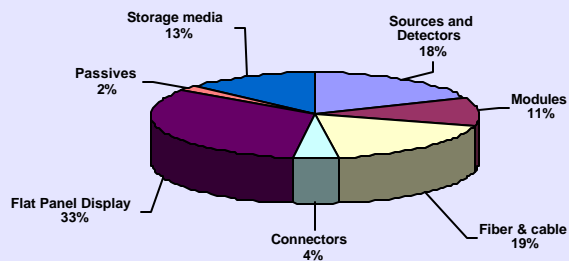


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990909di-a

Optoelectronics Components Market (1999)

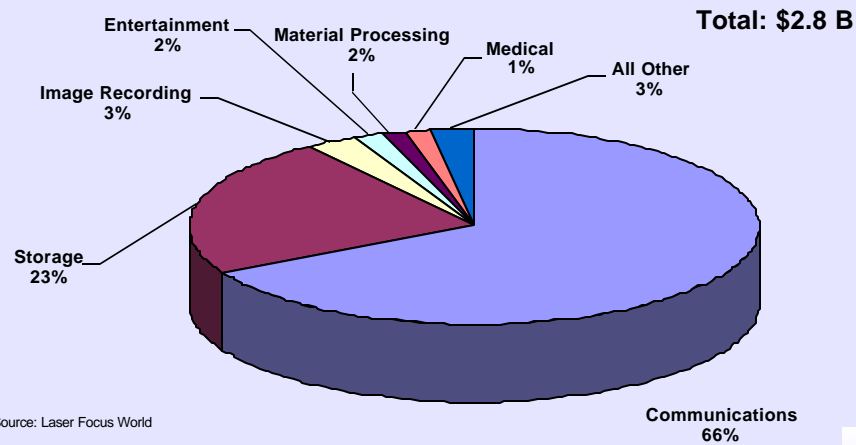
1999 \$47.9B Total



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990923FSW006

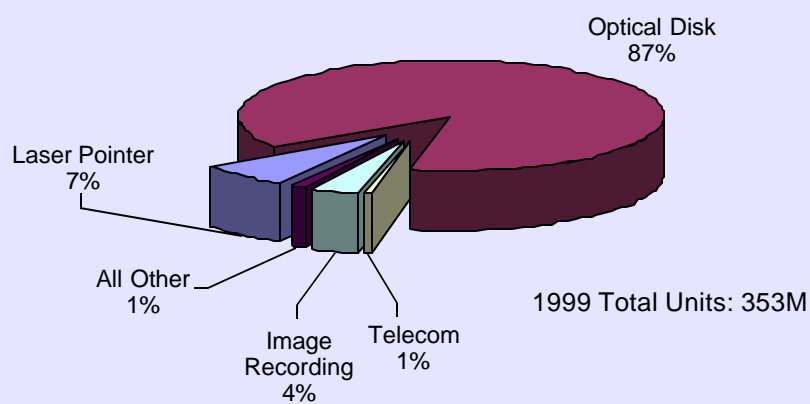
Diode Laser Revenues - 1999



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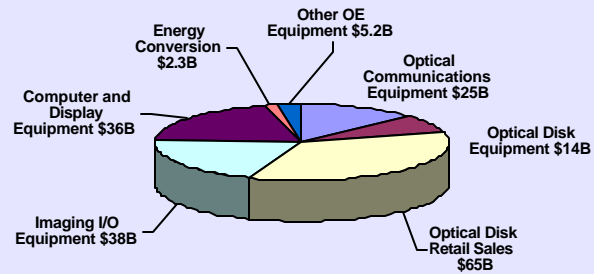
Unit Sales of Diode Lasers by Equipment Use



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Optoelectronic Equipment Revenues



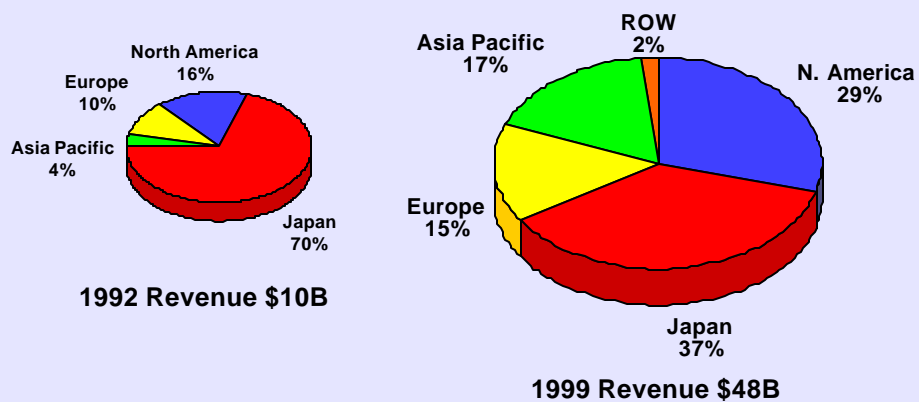
1999 Total \$186B

Preliminary OIDA Estimate

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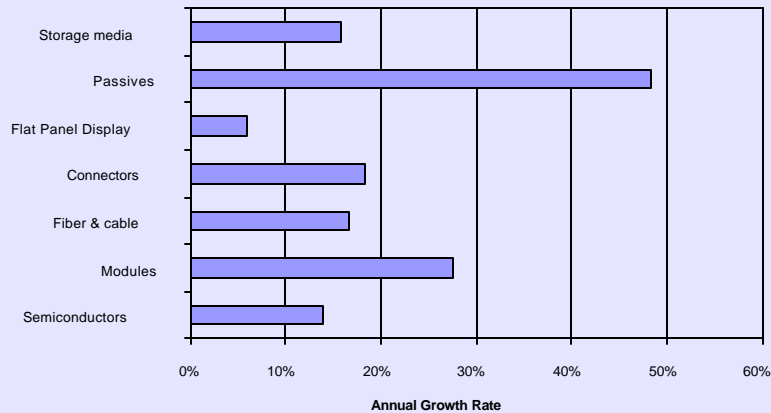
Regional OE Component Market Share



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OE Components Market Growth 1997-1999

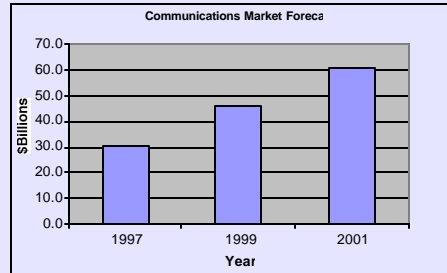
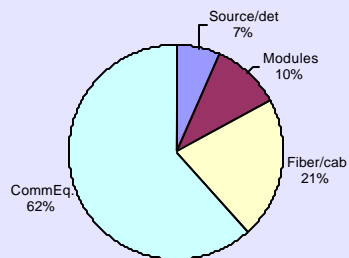


OE Product Growth Areas

- **Communications**
 - Dense Wave Division Multiplexing
 - LANs and Access
- **Imaging**
 - Computer peripherals
 - Digital Imaging
- **Optical Storage**
 - DVD
 - Rewritable disks
- **Display**
 - Flat panel monitors
 - Handheld and Small Displays

Optoelectronic Communications Market

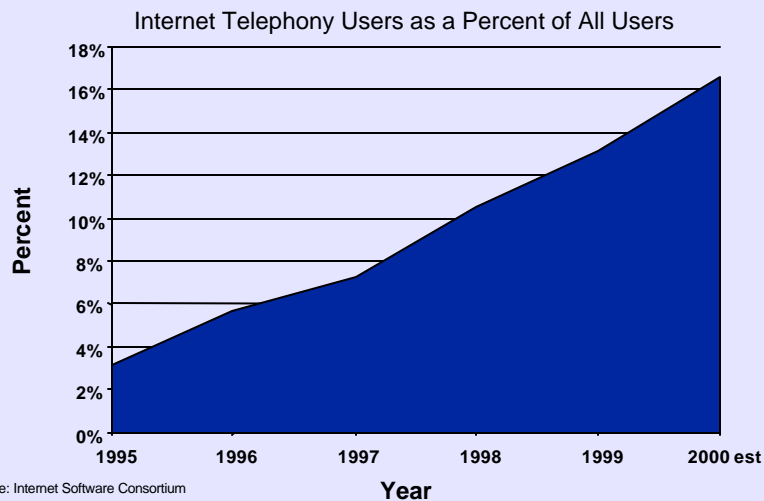
1997 Communications Market \$30.9B



Market Drivers for Communications

- Internet use increases demand on core network
- DWDM (favors electronics over additional fiber)
- Data network expansion
- Beginnings of access deployment

Penetration of Internet Telephony

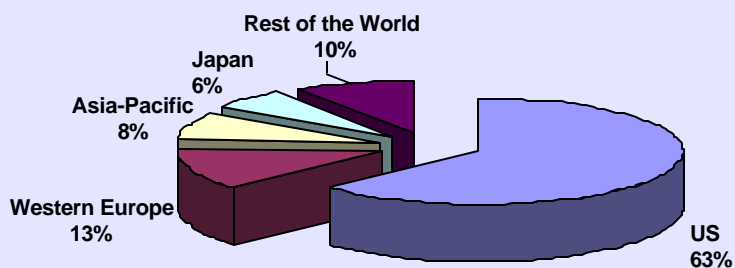


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E-Commerce Revenue

Forecast for 2002: \$319B



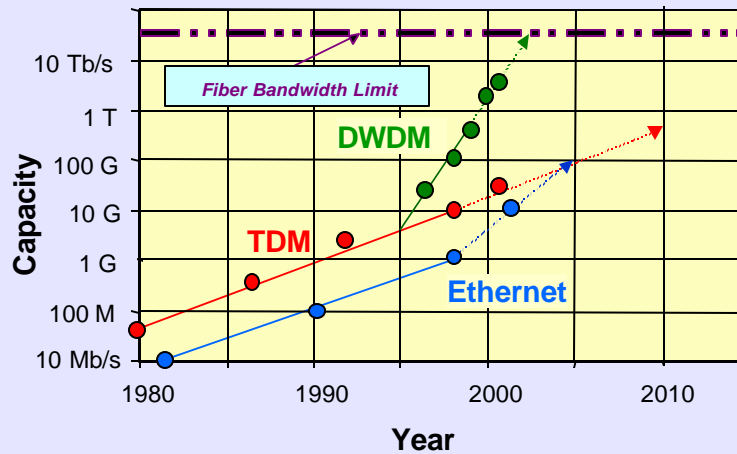
(1997 Figure: \$12B)

Source: IDC

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Communication Bandwidth Explosion

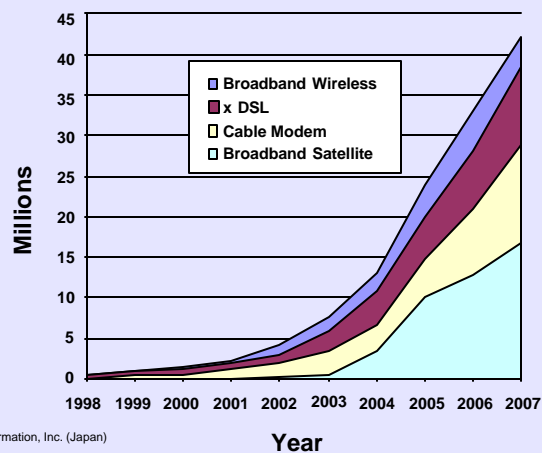


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U.S. Residential Broadband Access

Subscribers by Connection Type, 1998-2007

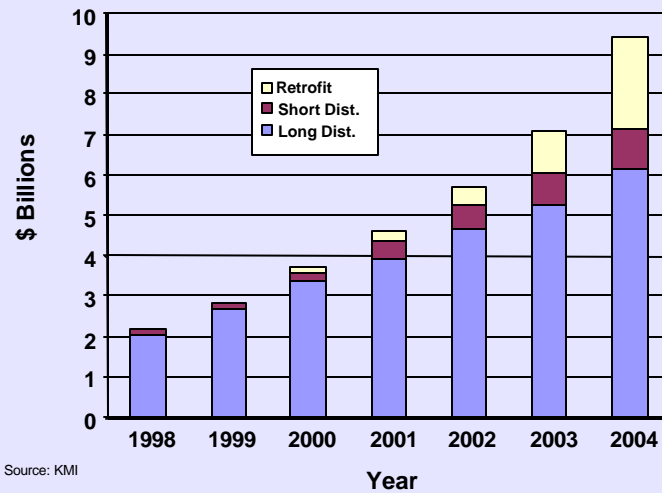


Source: Global Information, Inc. (Japan)

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DWDM Forecast 1998-2004

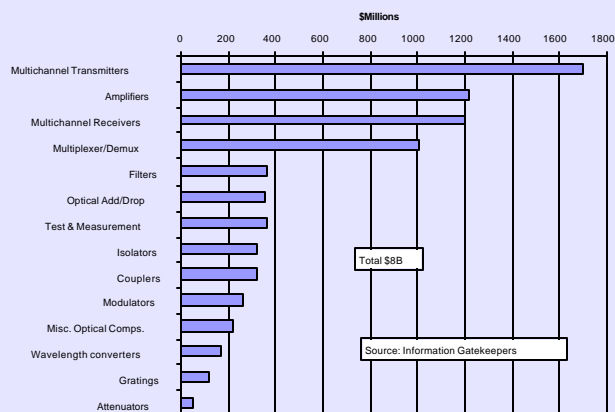


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DWDM Components Markets

DWDM Components Revenue Forecast for 2002

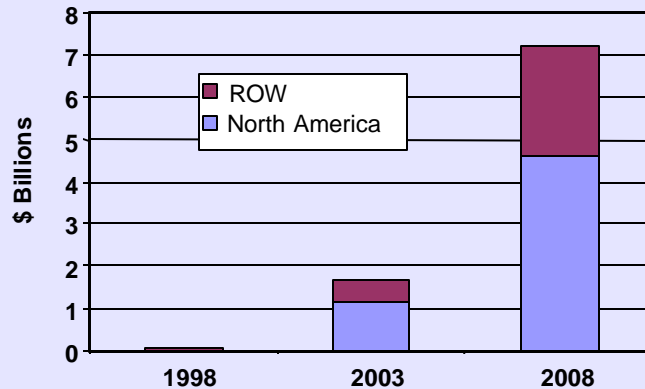


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Optical Add-Drop Multiplexing

Worldwide Equipment Revenue Forecast



Source: Electronicast

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Communications Roadmap Summary

■ Key Points

- Total fiber capacity will reach 10Tb/s by 2005
- The number of DWDM channels will rise to 500 or more
- Optical packet switching and other all optical functions will emerge over the next few years
- Transceiver costs will fall and low cost integrated components will emerge, opening new markets

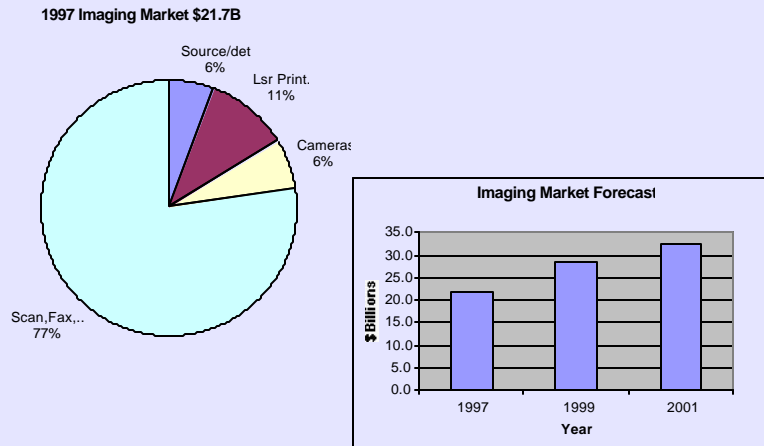
■ Major Efforts Needed

- High bit rate TDM
- Wavelength control for narrowly spaced channels
- All optical network equipment
- Integration and cost reduction of modules

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Optoelectronics Imaging Market



Market Drivers for Imaging

- Increased SOHO use of imaging equipment
- Growth of peripherals and multifunction equipment
- Increasing use of digital still camera
 - Growing personal use as a “digital hobby”
- Advanced Imaging Capabilities
 - New applications emerging for military, automotive, and other large markets

The Small Office/Home Office

- SOHO is the fastest-growing business environment
 - Defined as businesses with less than 20 employees
- Small business demographics
 - 41.3 Million people in 1999
 - Growing to 51.6 Million by 2002
 - 13% of Inc. Magazine's top 500 list of fastest growing companies have less than 20 employees
- 55% of SOHO owners purchased a computer within the last two years
 - Follow-on purchases of printers, scanners, etc., will benefit optoelectronics

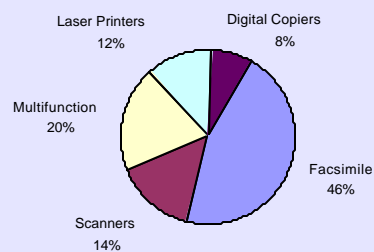
Source: IDC Research

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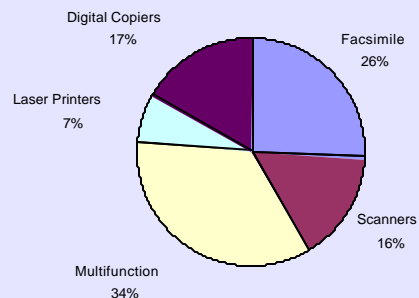
Subsegments of OE Peripheral Market

1997 Total \$18.5B



Source: CAP Ventures

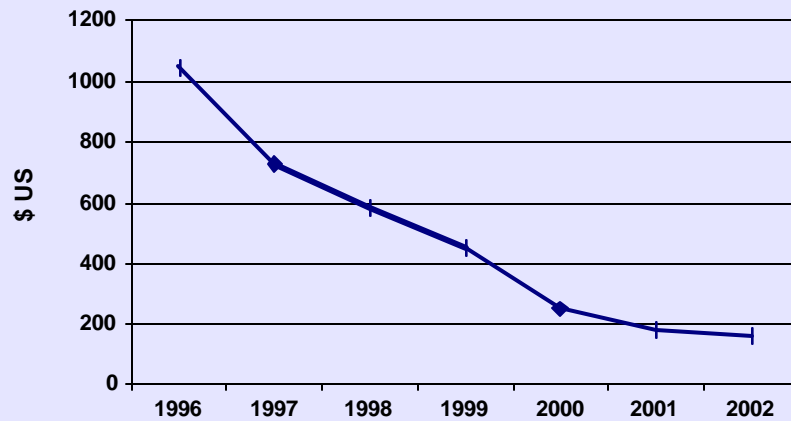
2001 Total \$28B



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Photo Quality Digital Camera Average Prices

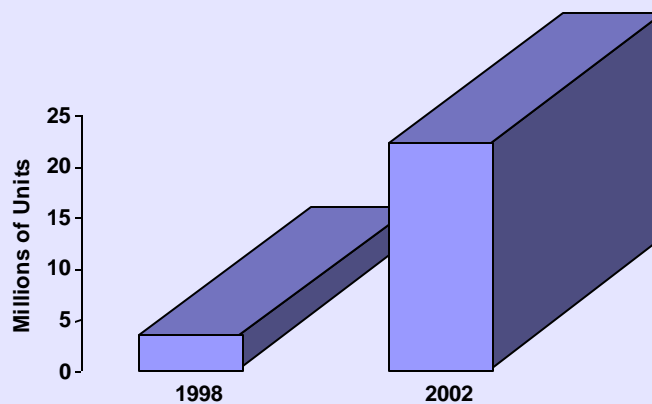


Source: IDC, 1998

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Worldwide Forecast for Digital Cameras



Source: IDC

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991005FSW019

Advanced Imaging Opportunities

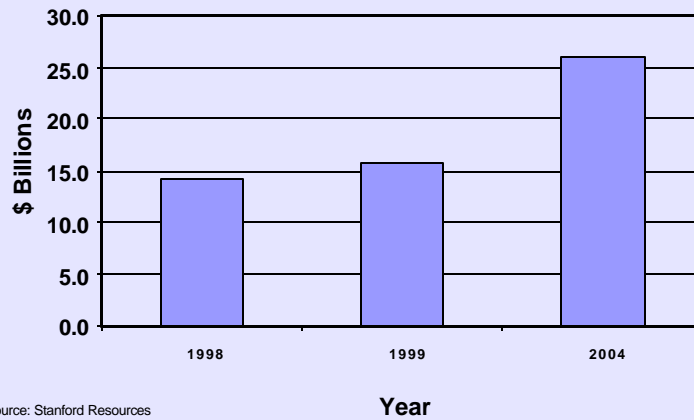
Findings of OIDA's Advanced Imaging Workshop:

- Higher spatial resolution for digital images will be possible and cost effective
- Fusing images in different spectral ranges will allow visualization of new details
- Signal processing will enable intelligent tracking and improved vision
- Miniature cameras with a high degree of integration and low cost will emerge

Drivers for the Flat Panel Display Market

- Growth of Portable Computers
- Increasing use of hand-held devices
- Reduced costs for flat panel monitors

Worldwide Flat Panel Display Forecast



Source: Stanford Resources

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Major Investments by Taiwan in OE

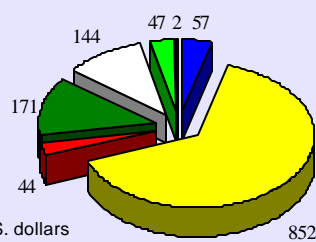
1997 Notable cases : 22

Total investment : 1,388
billion U.S. dollars

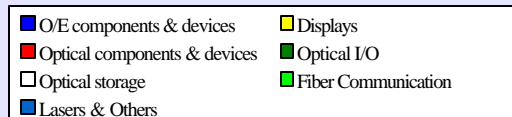


1998 Notable cases : 52

Total investment : 1,315
billion U.S. dollars



Unit: Million U.S. dollars



Source: Peter Shih, PIDA

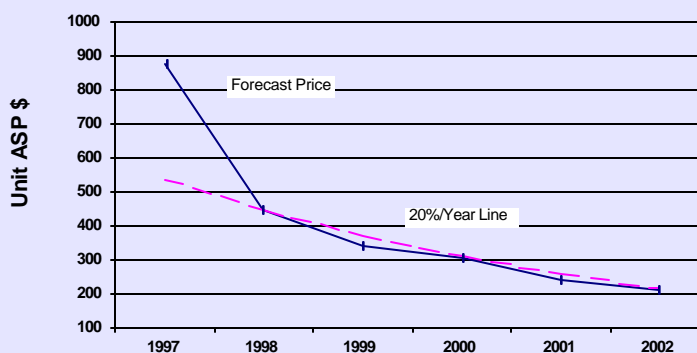
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Optical Storage Drivers

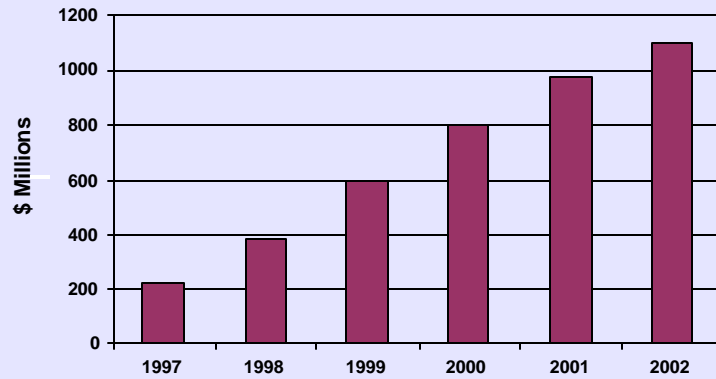
- Optical Disk for Software Distribution
- The Recordable CD is here
- Continued Entertainment Disk Growth
- The DVD - Finally!

DVD Drive Average Selling Price



Source: In-Stat

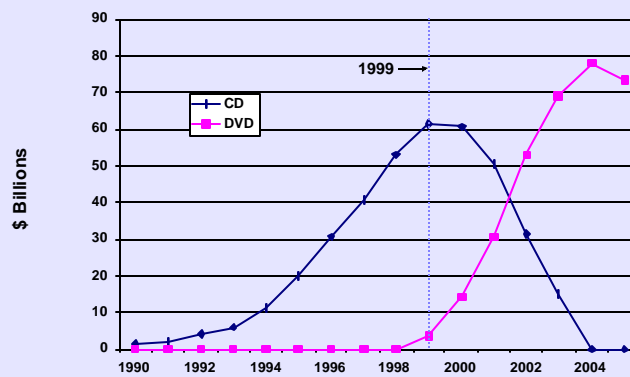
Forecast Revenues for DVD Drives



Source: In-Stat

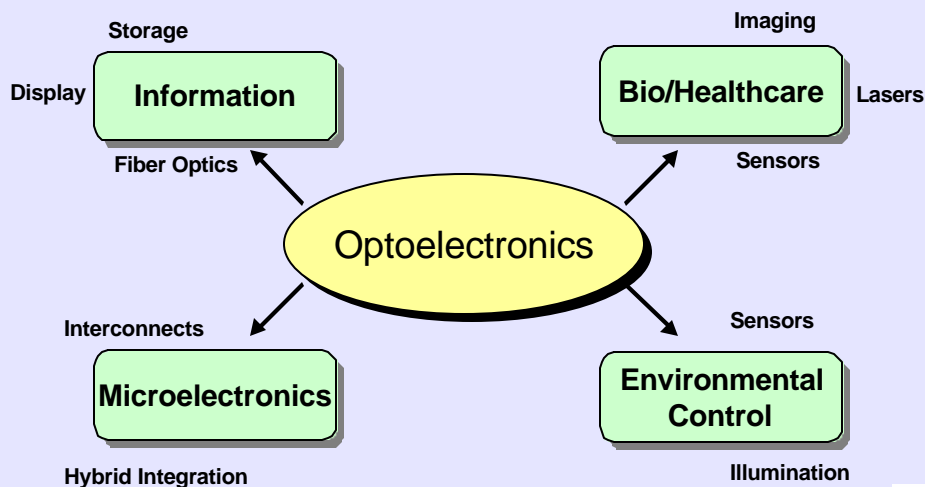
Worldwide Optical Disk Retail Sales

CD-ROM vs DVD-ROM Title Revenues



Source: InfoTech

Leading Technologies for the 21st Century



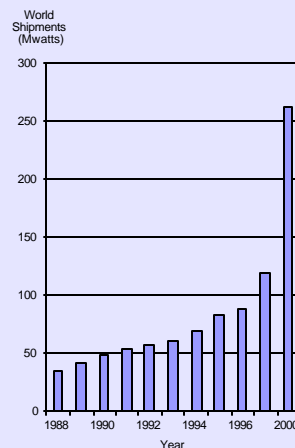
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Photovoltaics

- Annual sales of solar products today: \$1.1Billion
 - US Share is 44%
 - 60% of US sales are export
- Global market forecast by 2010: \$8-10 Billion
 - With recent innovations which lower cost: \$18Billion
 - Could grow faster with serious government efforts

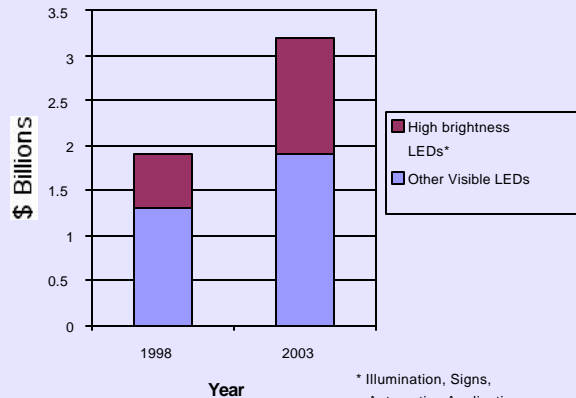
Sources: Solar Energy Industries Association; Photovoltaic Insiders Report



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Growing Market for High Brightness LEDs



Source: Strategies Unlimited

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Market Summary

- The worldwide optoelectronics market continues to expand
- Revenues for most segments are growing at double digit rates
- Optoelectronics is benefiting from the expanding information age
- The US is strongest in communications, but has significant shares in other applications as well
- Numerous emerging applications promise continued growth

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Key Issues for Competitiveness

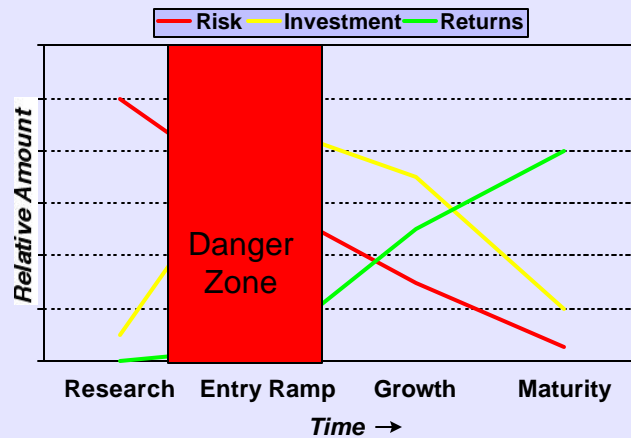
- A strong manufacturing infrastructure and efficient production is critical to successfully capture and maintain market share
- Large targeted capital investments are required for high volume markets
- Significant price erosion - 12 to 15% or more - is the norm for optoelectronics products

Manufacturing is Important

- The Optoelectronics-enabled worldwide *equipment* market is an estimated \$80B
 - The components portion is about 25%
- Optoelectronics is the underpinning of Information Age and Military Technologies
 - Also: Transportation, Entertainment, Medicine, Industrial applications, Consumer appliances

 *The largest markets require high-volume low-cost manufacture*

Product Stages



Cooperation vs. Competition

- | | |
|--|--|
| <p>■ Common Needs</p> <p><i>Cooperative Opportunity</i></p> <ul style="list-style-type: none"> ➢ Design tools ➢ Basic processes ➢ Test methods and equipment ➢ Parts and materials ➢ Standards ➢ Training and education | <p>■ Proprietary Activities</p> <p><i>The Competitive Edge</i></p> <ul style="list-style-type: none"> ➢ Product design ➢ Product enhancements ➢ Manufacturing efficiency improvements ➢ Supply line management ➢ Applications assistance ➢ Market introduction/trials |
|--|--|

☆ Competition is mostly based on *Product*, not *Process*

Conclusion

- Optoelectronics is a thriving worldwide industry
- North America's relative market share is growing
- A strong infrastructure in manufacturing, research and product development is key to sustaining growth
- Cooperative programs in pre-competitive high-risk technologies, like ATP's program in photonics manufacturing, can help